APPENDIX 8-A. INSTALLATION COST DETERMINATION

TABLE OF CONTENTS

8-A.1 INTRODUCTION 8-A-1
8-A.2 GAS-FIRED STORAGE WATER HEATERS 8-A-1
8-A.2.1 Basic Installation Costs 8-A-1
8-A.2.2 Venting 8-A-2
8-A.2.2.1 New Construction 8-A-2
8-A.2.2.2 Replacement 8-A-4
8-A.2.3 Drain Pan 8-A-5
8-A.2.4 Electricity Outlet 8-A-5
8-A.2.5 Condensate Disposal 8-A-6
8-A.2.6 Additional Costs Associated with Space Constraints 8-A-6
8-A.3 ELECTRIC STORAGE WATER HEATERS 8-A-7
8-A.3.1 Basic Installation Costs 8-A-8
8-A.3.1.2 Drain Pan Incremental Costs 8-A-8
8-A.3.2 Additional Costs Associated with Space Constraints 8-A-10
8-A.3.3 Incremental Installation Costs for Heat Pump Water Heaters 8-A-12
8-A.3.3.1 Additional Labor Hours 8-A-12
8-A.3.3.2 Condensate Pump Cost 8-A-13
8-A.3.3.3 Costs for Addressing Heat Pump Water Heater Space Constraints 8-A-13
8-A.3.3.4 Venting System Adder 8-A-14
8-A.3.3.5 Drain Pan Incremental Cost 8-A-15
8-A.4 OIL-FIRED STORAGE WATER HEATERS 8-A-15
8-A.5 INSTANTANEOUS GAS WATER HEATERS 8-A-15
8-A.6 DIRECT HEATING EQUIPMENT 8-A-16
8-A.7 POOL HEATERS 8-A-17
8-A.8 RS MEANS 2009 REGIONAL LABOR COSTS 8-A-18

LIST OF TABLES

Table 8-A.2.1 Basic Installation Cost: New Construction 8-A-1
Table 8-A.2.2 Basic Installation Costs: Replacement 8-A-2
Table 8-A.2.3 Installation Adder for 65 and 75 Gal Gas-Fired Water Heaters or Attic Installation 8-A-2
Table 8-A.2.4 Natural Draft Venting Costs (Typical 2-Story House): New Construction 8-A-3
Table 8-A.2.5 Plastic Venting Costs: New Construction 8-A-3
Table 8-A.2.6 Stainless Steel Vent Connector Cost Adder: New Construction 8-A-3
Table 8-A.2.7 Stainless Steel Vent Connector Costs: Replacement 8-A-4
Table 8-A.2.8 Plastic Venting Costs: Replacement 8-A-4
Table 8-A.2.9 Concealing Ductwork Costs: Replacement 8-A-4
Table 8-A.2.10 Drain Pan Cost for Increasing to 2 inch Insulation 8-A-5
Table 8-A.2.11 Installation Costs for Adding an Electrical Outlet (New Construction) 8-A-5

Table 8-A.2.12 Installation Costs for Adding an Electrical Outlet (Replacement) 8-A-5
Table 8-A.2.13 Installation Costs for Electricity Grounding (Replacement) 8-A-5
Table 8-A.2.14 Space Constraint Costs: Use of Tempering Valve..... 8-A-7
Table 8-A.2.15 Space Constraint Costs: Door Modifications – Door Jambs 8-A-7
Table 8-A.3.1 Average Basic Installation Costs: New Construction..... 8-A-8
Table 8-A.3.2 Basic Installation Costs for Electric Storage Water Heater: Replacement..... 8-A-8
Table 8-A.3.3 Installation Adder (66, 75 and 119-gallon) or Attic Installation 8-A-8
Table 8-A.3.4 Electric Storage Water Heater Diameter Fractions by Rated Volume 8-A-9
Table 8-A.3.5 Electric Storage Water Heater Drain Pan Diameter by Rated Volume 8-A-9
Table 8-A.3.6 Electric Storage Water Heater Drain Pan Cost Table (2009$) 8-A-9
Table 8-A.3.7 Drain Pan Incremental Cost for Wider Electric Storage Water Heaters.. 8-A-10
Table 8-A.3.8 Space Constraint Costs: Use of Tempering Valve..... 8-A-11
Table 8-A.3.9 Space Constraint Costs: Door Modifications – Door Jambs 8-A-12
Table 8-A.3.10 Installation Adder for Heat Pump Water Heaters..... 8-A-12
Table 8-A.3.11 Space Constraint Costs: Closet Modifications – Louvered Door..... 8-A-13
Table 8-A.3.12 Heat Pump Water Heater Venting Installation Cost Adder (Average).... 8-A-14
Table 8-A.3.13 Costs of Concealing HPWH Venting 8-A-15
Table 8-A.7.1 New Construction Costs (Low Cost, 90% of Installations)..... 8-A-17
Table 8-A.7.2 Replacement Costs (Low Cost, 90% of Installations) 8-A-17
Table 8-A.7.3 New Construction Costs for Electricity Connections 8-A-18
Table 8-A.7.4 Replacement Costs for Electricity Connections 8-A-18
Table 8-A.8.1 RS Means 2009 National Average Labor Costs by Crew (Standard Union) 8-A-19
Table 8-A.8.2 RS Means Labor Costs Markups by Trade (Standard Union) 8-A-19
Table 8-A.8.3 Final Labor Cost Factors by Census Division and Four Large States 8-A-19
Table 8-A.8.4 Final Labor Cost Factors by Census Division and Four Large States 8-A-20

APPENDIX 8-A. INSTALLATION COST DETERMINATION

8-A.1 INTRODUCTION

This appendix provides further details about the derivation of installation cost for residential water heaters, direct heating equipment, and pool heaters.

The labor costs shown in the tables in this appendix are the national-average values. In its analysis, DOE used regional labor costs to more accurately estimate installation costs by region. Section 8-A.8 describes the derivation of regional labor costs. DOE then applied the appropriate regional labor cost to each RECS sample household. The total costs include overhead and profit (O&P). (Note that the unit "L.F." in the tables means "linear foot.")

8-A.2 GAS-FIRED STORAGE WATER HEATERS

DOE developed installation cost data for gas-fired storage water heaters using RS Means books,[1, 2, 3, 4, 5] DOE technical support documents,[1, 2, 3, 4, 5] and a consultant report prepared for this analysis.[1, 2, 3, 4, 5]

8-A.2.1 Basic Installation Costs

For water heaters installed in new construction, the basic installation costs include putting in place and setting up the new water heater, adding water piping, and adding a gas line branch. Table 8-A.2.1 shows the installation costs for new construction calculated using RS Means.

Table 8-A.2.1 Basic Installation Cost: New Construction

Description	Crew	Labor Hours	Unit	Bare Costs *(2009$)*			Total incl. O&P
				Mat.	Labor	Total	
Basic Installation Cost	2 PLUM*	2.50	--	25.00	126.42	151.42	$217.26
Water Piping (Schedule 40, threaded, with couplings, and clevis hanger, 3/4" diameter)	2 PLUM	0.13	L.F.	2.58	6.62	9.20	$63.91
Gas Piping (1/2" diameter, Schedule 40, threaded, with couplings, and clevis type hangars, 10' O.C., black)	1 PLUM	0.13	L.F.	2.18	6.42	8.60	$60.19
Gas Piping (Ground-joint union, 1/2")	1 PLUM	0.57	L.F.	15.50	28.87	44.37	$60.39
Totals		3.33		45.26	168.33	213.59	**$401.75**

* 1 PLUM means a crew of 1 plumber.

Table 8-A.2.2 shows the basic installation cost for replacement cases, which includes the labor costs for disconnecting and removing the old water heater, and putting in place and setting up the new water heater. In addition, DOE included removal/disposal fees ($35) and permit fees ($35).

Table 8-A.2.2 Basic Installation Costs: Replacement

Description	Crew	Labor Hours	Unit	Bare Costs *(2009$)*			Total incl. O&P
				Mat.	Labor	Total	
Trip Charge	2 PLUM*	1.00	--	0.00	50.57	50.57	$75.90
Remove Old Water Heater	2 PLUM	1.25	--	0.00	63.21	63.21	$94.88
Installation	2 PLUM	2.50	--	25.00	126.42	151.42	$217.26
Removal/Disposal and Permit Fees							**$70.00**
Totals		4.75		25.00	240.20	265.20	**$458.04**

* 1 PLUM means a crew of 1 plumber.

DOE included an additional cost for 65 and 75-gallon gas-fired water heaters or attic installation that takes into account one additional hour of labor for the extra time needed to install this larger equipment (Table 8-A.2.3).

Table 8-A.2.3 Installation Adder for 65 and 75 Gal Gas-Fired Water Heaters or Attic Installation

Description	Crew	Labor Hours	Unit	Bare Costs *(2009$)*			Total incl. O&P
				Mat.	Labor	Total	
66 and 75-Gallon Adder	2 PLUM*	1	--	0.00	50.57	50.57	**$75.90**

* 1 PLUM means a crew of 1 plumber.

8-A.2.2 Venting

DOE calculated venting costs for each household in the sample. DOE used a number of variables, including vent location, installation type, connection type, region, venting material, and chimney type to determine venting costs for both new construction and replacement installations. DOE also considered if the water heater would require a stainless steel vent connector. Regarding atmospheric venting at Efficiency Level 2, DOE assumed that a stainless steel vent connector would be required for all models with RE of 78 percent and higher. Applying this assumption resulted in DOE using a cost for a stainless steel vent connector for 57 percent of installations at Efficiency Level 2, for 53 percent of installations at Efficiency Level 1, and for 24 percent of installations at baseline level.

8-A.2.2.1 New Construction

For natural draft venting in new construction, DOE accounted for both commonly vented water heaters (together with a central furnace) and isolated water heaters (separately vented). Table 8-A.2.4 shows the installation costs for the venting component of a natural draft gas-fired storage water heater in a typical cost for a two-story house without a chimney. Table 8-A.2.4 shows the installation costs for the venting component of a natural draft gas-fired storage water heater in a typical cost for a two-story house without a chimney. Table 8-A.2.5 shows the typical installation costs for the venting component of a power vent (plastic venting) gas-fired storage water heater. Table 8-A.2.6 shows the added cost in new construction from having a stainless steel vent connector versus the baseline type-B vent connector.

Table 8-A.2.4 Natural Draft Venting Costs (Typical 2-Story House): New Construction

Description	Crew	Labor Hours	Unit	Bare Costs *(2009$)*			Total incl. O&P
				Mat.	Labor	Total	
Vent chimney, double wall, galvanized steel (4" Diameter)	Q9*	0.24	L.F.	5.95	10.35	16.30	$346.52
Double Wall, Galvanized Steel Adjustable Length piece, to 12"	Q9	0.47	Ea.	11.45	20.75	32.20	$44.53
Type B Wall Thimble, 4" to 7" Adjustable(4" Diameter)	Q9	0.47	Ea.	13.90	20.75	34.65	$94.46
Vent Connector (Type B Elbows, 45 degree, 4" Diameter)	Q9	0.47	Ea.	13.95	20.75	34.70	$47.28
Roof Flashing (4" Diameter)	Q9	0.47	Ea.	8.05	20.75	28.80	$40.79
Tee (4" Diameter)	Q9	0.62	Ea.	30.00	27.10	57.10	$149.40
Tee Cap (4" Diameter)	Q9	0.38	Ea.	2.34	16.79	19.13	$28.41
Top (4" Diameter)	Q9	0.36	Ea.	11.45	16.04	27.49	$37.28
Simulated brick Chimney top, 4' high, 16' x 16'	1 CARP**	0.80	Ea.	237.00	33.15	270.15	$0.00
Total				334.09	186.43	520.52	**$788.67**

* 1 Q9 means a crew comprised of 1 sheet metal worker and 1 sheet metal worker apprentice.
** 1 CARP means a crew of 1 carpenter.

Table 8-A.2.5 Plastic Venting Costs: New Construction

Description	Crew	Labor Hours	Unit	Bare Costs *(2009$)*			Total incl. O&P
				Mat.	Labor	Total	
PVC, couplings 10' O.C., hangars 3 per 10', schedule 40 (2" Diameter)	Q1*	0.08	L.F.	1.21	3.69	4.90	$128.52
PVC, schedule 40, socket joints, 90" elbow, 1/2" (2" diameter)	Q1	0.44	Ea.	2.18	20.03	22.21	$64.91
Total		0.52		3.39	23.72	27.11	**$193.43**

* 1 Q1 means a crew comprised of 2 plumbers and 1 plumber apprentice.

Table 8-A.2.6 Stainless Steel Vent Connector Cost Adder: New Construction

Description	Crew	Labor Hours	Unit	Bare Costs *(2009$)*			Total incl. O&P
				Mat.	Labor	Total	
Vent Connector (Vent chimney, double wall, type B, 4" Diameter)	Q9*	0	L.F.	11.90	0.00	11.90	$58.91
Vent Connector (Type B Elbows, 45 degree, 4" Diameter)	Q9	0	Ea.	27.90	0.00	27.90	$30.69
Total		0		39.80	0.00	39.80	**$89.60**

* 1 Q9 means a crew comprised of 1 sheet metal worker and 1 sheet metal worker apprentice.

8-A.2.2.2 Replacement

For natural draft venting in replacement installations, DOE added the cost of having to install a stainless steel vent connector versus the baseline type-B vent connector (see Table 8-A.2.7). For power vent (plastic vent) installations, DOE added the cost of adding a complete plastic vent system (Table 8-A.2.8) and for about 25 percent of the indoor installations also added the cost of concealing the venting system (Table 8-A.2.9).

Table 8-A.2.7 Stainless Steel Vent Connector Costs: Replacement

Description	Crew	Labor Hours	Unit	Bare Costs *(2009$)*			Total incl. O&P
				Mat.	Labor	Total	
Vent Connector (Vent chimney, double wall, type B, 3" Diameter)	Q9*	0.24	L.F.	17.85	10.35	28.20	$160.06
Vent Connector (Type B Elbows, 45 degree, 3" Diameter)	Q9	0.47	Ea.	41.85	20.75	62.60	$77.97
Total		0.71		59.70	31.10	90.80	**$238.04**

* 1 Q9 means a crew comprised of 1 sheet metal worker and 1 sheet metal worker apprentice.

Table 8-A.2.8 Plastic Venting Costs: Replacement

Description	Crew	Labor Hours	Unit	Bare Costs *(2009$)*			Total incl. O&P
				Mat.	Labor	Total	
PVC, couplings 10' O.C., hangars 3 per 10', schedule 40 (2" Diameter)	Q1*	0.08	L.F.	1.21	3.69	4.90	$128.52
PVC, schedule 40, socket joints, 90" elbow, 1/2" (2" diameter)	Q1	0.44	Ea.	2.18	20.03	22.21	$97.37
Knockouts to 8' high, metal boxes & enclosures (With hole saw, 2" pipe size)	1 ELEC**	0.30	Ea.	0.00	14.43	14.43	$42.95
Total				3.39	38.15	41.54	**$268.83**

* 1 Q1 means a crew comprised of 2 plumbers and 1 plumber apprentice.
** 1 ELEC means a crew of 1 electrician.

Table 8-A.2.9 Concealing Ductwork Costs: Replacement

Description	Crew	Labor Hours	Unit	Bare Costs *(2009$)*			Total incl. O&P
				Mat.	Labor	Total	
Trip Charge	1 CARP*	0.5	Ea.	0.00	20.72	20.72	$32.14
Wallboard repair 8"-12" (cut square, patch san and repair finish)	1 CARP	0.5	C.L.F.	3.04	20.72	23.76	$380.44
Total		1.0		3.04	41.44	44.48	**$412.57**

* 1 CARP means a crew of 1 carpenter.

8-A.2.3 Drain Pan

Some houses may require a replacement drain pan of a larger size when a wider, more efficient (due to increased insulation thickness) water heater is installed. DOE used the approach applied in the 2001 water heater rulemaking[3] to develop average drain pan prices for increasing to 2 inch insulation by tank size (Table 8-A.2.10).

Table 8-A.2.10 Drain Pan Cost for Increasing to 2 inch Insulation

Tank Size *(gal)*	**Average Price** *(2009$)*
30	0.75
40	1.90
50	3.77
66	5.32
75	6.87

8-A.2.4 Electricity Outlet

DOE added an additional cost for labor and wiring for installing an electrical outlet for new construction (Table 8-A.2.11) and for existing houses that do not have electricity close to the water heater (Table 8-A.2.12). DOE estimated that all households that do not have a gas furnace or boiler would require an electrical outlet and calculated the additional cost of the outlet using RS Means.[5] DOE estimated that grounding for an electrical outlet (Table 8-A.2.13) is needed for houses built before 1960.[6]

Table 8-A.2.11 Installation Costs for Adding an Electrical Outlet (New Construction)

Description	**Crew**	**Labor Hours**	**Unit**	**Bare Costs** *(2009$)*			**Total incl. O&P**
				Mat.	**Labor**	**Total**	
Receptacle Devices	1 ELEC*	1.5	Ea.	29.50	73.18	102.68	**$141.34**

* 1 ELEC means a crew of 1 electrician.

Table 8-A.2.12 Installation Costs for Adding an Electrical Outlet (Replacement)

Description	**Crew**	**Labor Hours**	**Unit**	**Bare Costs** *(2009$)*			**Total incl. O&P**
				Mat.	**Labor**	**Total**	
Trip Charge	1 ELEC*	0.50	L.F.	0.00	24.38	24.38	$36.27
Receptacle Devices	1 ELEC	1.50	Ea.	29.50	73.18	102.68	$141.34
Total		2.00		29.50	97.56	127.06	**$177.61**

* 1 ELEC means a crew of 1 electrician.

Table 8-A.2.13 Installation Costs for Electricity Grounding (Replacement)

Description	**Crew**	**Labor Hours**	**Unit**	**Bare Costs** *(2009$)*			**Total incl. O&P**
				Mat.	**Labor**	**Total**	
Clamp, bronze, 1/2" diameter	1 ELEC*	0.25	Ea.	4.60	12.19	16.79	$23.20
Bare copper wire, #14 solid	1 ELEC	0.57	C.L.F.	8.30	27.84	36.14	$12.64
Total		0.82		12.90	40.03	52.93	**$35.83**

* 1 ELEC means a crew of 1 electrician.

8-A.2.5 Condensate Disposal

The installation cost for the condensing design includes the cost of the condensate disposal. The approach reflects the currently available condensing water heater design that utilizes a single pipe power vent design. The condensate disposal includes the cost of the condensate neutralizer filter, which is required by some codes. The condensate disposal includes the cost of the condensate neutralizer filter, which is required by some codes. DOE applied a condensate filter cost of $86 to 25 percent of the installations.

8-A.2.6 Additional Costs Associated with Space Constraints

In some houses, the original water heater location may be too small to accommodate a replacement water heater of the same rated volume when the new water heater's insulation thickness is 1.5 or 2 inches. Based on the consultant report, an estimated 15-25% of all replacement installations would require significant modifications in order to install a larger sized gas storage water heater with 2 in. insulation. DOE estimated that such constraints would apply to half of the above fraction for replacement water heater installations with 1.5 in. insulation.

In situations where significant modifications would be required, there are a number of possibilities that might be applicable to the individual installation. These include:

1) Installing a water heater with different dimensions (e.g., installing a taller unit).
2) Installing a water heater with a smaller rated volume, increasing the setpoint, and adding a tempering valve to provide hot water at the desired temperature.
3) Installing a water heater with a smaller rated volume with a similar first hour rating as the existing unit (by either having a higher input capacity or more efficient burner)
4) Modifying the existing water heater installation location (primarily removing/replacing door jambs).
5) Relocating the water heater.
6) Switching to an electric or gas-fired instantaneous water heater or electric storage water heater.

After considering that some houses could choose a different dimension water heater (option 1), DOE assumed that, for non-manufactured homes, major modifications would be necessary for 20 percent of replacement installations with 2-inch insulation and for 10 percent of replacement installations with 1.5-inch insulation. Because manufactured homes encounter space constraints more often, DOE assumed that major modifications would be necessary for 40 percent of replacement installations with 2-inch insulation and for 20 percent of replacement installations with 1.5-inch insulation.

For those households facing major modifications, DOE estimated that half of the cases would choose option 2 (smaller water heater with tempering valve) or option 3 (smaller water heater with similar first hour rating as the existing unit) and half would select option 4 (door jamb removal/replacement). For single-family and multi-family homes, DOE estimated that option 4 would be selected only in cases where the water heater is installed in an indoor closet or attic (e.g., not in a garage or basement).

For option 2, DOE did not adjust the setpoint in its energy use calculations or change the equipment cost for the smaller water heater, as DOE believes these two factors would offset.[a] For option 3, DOE used the cost of installing tempering valves as a proxy for the increase in equipment cost that would be associated with this option (DOE believes that the cost of adding the tempering valve would be in most cases greater than the cost of implementing option 3). DOE estimated that the added the cost of adding a tempering valve as shown in Table 8-A.2.14.

Table 8-A.2.14 Space Constraint Costs: Use of Tempering Valve

Description	Crew	Labor Hours	Unit	Bare Costs *(2009$)*			Total incl. O&P
				Mat.	Labor	Total	
Trip Charge	1 PLUM*	0.5	L.F.	0.00	25.28	25.28	$37.95
Tempering, water, sweat connections (3/4")	1 PLUM	0.4	L.F.	79.50	20.23	99.73	$117.81
Total		0.9		79.50	45.51	125.01	**$155.76**

* 1 PLUM means a crew of 1 plumber.

DOE estimated the cost for option 4 (door jamb removal/replacement) as shown in Table 8-A.2.1515.

Table 8-A.2.15 Space Constraint Costs: Door Modifications – Door Jambs

Description	Crew	Labor Hours	Unit	Bare Costs *(2009$)*			Total incl. O&P
				Mat.	Labor	Total	
Trip Charge	1 CARP*	0.5	L.F.	0.00	20.72	20.72	$32.14
Remove and replace interior door casing, jamb and stop	1 CARP	1.2	L.F.	0.00	49.73	49.73	$77.13
Remove and replace interior slab door, on existing hinges (includes new door)	1 CARP	2.0	L.F.	0.00	82.88	82.88	$128.55
Total		3.7		0.00	153.33	153.33	**$237.81**

* 1 CARP means a crew of 1 carpenter.

8-A.3 ELECTRIC STORAGE WATER HEATERS

DOE developed installation cost data for electric storage water heaters using RS Means books,[1, 2, 3, 4, 5] DOE technical support documents,[1, 2, 3, 4, 5] and a consultant report prepared for this analysis.[1, 2, 3, 4, 5]

[a] The tempering valve strategy involves increasing the setpoint temperature so that the total energy content of the water that can be delivered from the smaller water heater is equivalent to the content delivered by the original water heater at a lower temperature. Increasing the setpoint temperature will increase the water heater standby losses, which is generally offset by lower equipment cost for the smaller water heater.

8-A.3.1 Basic Installation Costs

For new construction water heaters, the basic installation cost includes adding water piping in addition to putting in place and setting up the new water heater. Table 8-A.3.1 shows the installation costs for new construction calculated using RS Means.

Table 8-A.3.1 Average Basic Installation Costs: New Construction

Description	Crew	Labor Hours	Unit	Bare Costs *(2009$)*			Total incl. O&P
				Mat.	Labor	Total	
Basic Installation Costs	2 PLUM*	1.50	Ea.	25.00	63.45	88.45	$122.75
Water Piping (Schedule 40, threaded, with couplings, and clevis hanger, 3/4" diameter)	2 PLUM	0.13	L.F.	2.58	5.54	8.12	$55.78
Total		1.63		27.58	68.99	96.57	**$178.53**

* 1 PLUM means a crew of 1 plumber.

Table 8-A.3.2 shows the basic installation cost for all replacement cases, which includes the costs for putting in place and setting up the new water heater disconnecting and removing the old water heater. In addition, DOE included removal/disposal fees ($35) and permit fees ($35).

Table 8-A.3.2 Basic Installation Costs for Electric Storage Water Heater: Replacement

Description	Crew	Labor Hours	Unit	Bare Costs *(2009$)*				Total incl. O&P
				Mat.	Labor	Other	Total	
Trip Charge	2 PLUM*	1.00	Ea.	0.00	42.30	0.00	42.30	$63.50
Remove Old Heater	2 PLUM	0.75	Ea.	0.00	31.73	0.00	31.73	$47.62
Installation	2 PLUM	1.50	Ea.	25.00	63.45	0.00	88.45	$122.75
Removal/disposal and permit fees	-	-	Ea.	0.00	0.00	70.00	70.00	$70.00
Total		3.25		25.00	137.48	70.00	232.48	**$303.87**

* 1 PLUM means a crew of 1 plumber.

DOE added an additional cost for installation of 66, 75, and 119-gallon electric water heaters, which takes into account one additional hour of labor for the extra time to install this larger equipment (Table 8-A.3.3). The same additional cost is added to all attic installations.

Table 8-A.3.3 Installation Adder (66, 75 and 119-gallon) or Attic Installation

Description	Crew	Labor Hours	Unit	Bare Costs *(2009$)*			Total incl. O&P
				Mat.	Labor	Total	
Installation Adder	2 PLUM*	1	Ea.	0.00	42.30	42.30	**$63.50**

* 1 PLUM means a crew of 1 plumber.

8-A.3.1.2 Drain Pan Incremental Costs

DOE assumed that all electric storage water heater installations require a drain pan. When a wider (due to increased insulation thickness) water heater is installed, a larger and more expensive drain pan is required. DOE used the same approach as applied in the 2001 rulemaking

to derive incremental drain pan installation costs. DOE first derived average tank widths for each efficiency level as shown in Table 8-A.3.4. Tank widths at each rated volume vary, so DOE used the largest tank diameter for each size to determine the average drain pan diameter.

Table 8-A.3.4 Electric Storage Water Heater Diameter Fractions by Rated Volume

Tank Diameter	Rated Volume (gal)						minimum drain pan diameter
	<30	30	40	50	65	80	
12	60%						16
14	40%	80%					18
16		20%	80%	70%			20
18			20%	30%	90%		22
20					10%	90%	24
22						10%	26
24							28

Table 8-A.3.5 shows the selected average drain pan diameter for the baseline water heater with 1.5 inch insulation and for units with larger insulation thicknesses.

Table 8-A.3.5 Electric Storage Water Heater Drain Pan Diameter by Rated Volume

Insulation Thickness	Rated Volume (gal)				
	30	40	50	65	80
baseline (1.5")	20”	22”	22”	24”	26”
2"	22”	24”	24”	26”	28”
2.5-4"	24”	26”	26”	28”	30”

Table 8-A.3.6 shows the drain pan costs by diameter as gathered in 1998 during the 2001 water heater rulemaking.

Table 8-A.3.6 Electric Storage Water Heater Drain Pan Cost Table (2009$)

Nominal Size	radius	Price	Material	Source	Manufacturer
22	11	$18.23	Aluminum	Grainger	PLASTIC ODDITIES
24	12	$20.39	Aluminum	Grainger	PLASTIC ODDITIES
26	13	$12.96	Aluminum	Grainger	PLASTIC ODDITIES
30	15	$27.53	Aluminum	Grainger	PLASTIC ODDITIES
36	18	$43.99	Aluminum	Grainger	PLASTIC ODDITIES
24	12	$18.61	Aluminum	Home Depot	Oatey
24	12	$9.98	Aluminum	Lowes	Plastic Oddities Inc.
18	9	$15.75	Aluminum	Plastic Oddities Inc.	Plastic Oddities Inc.
20	10	$16.80	Aluminum	Plastic Oddities Inc.	Plastic Oddities Inc.
22	11	$17.85	Aluminum	Plastic Oddities Inc.	Plastic Oddities Inc.
24	12	$18.90	Aluminum	Plastic Oddities Inc.	Plastic Oddities Inc.
26	13	$27.26	Aluminum	Plastic Oddities Inc.	Plastic Oddities Inc.
30	15	$62.16	Aluminum	Plastic Oddities Inc.	Plastic Oddities Inc.

36	18	$65.73	Aluminum	Plastic Oddities Inc.	Plastic Oddities Inc.
24	12	$11.19	Plastic	Ace Hardware	Plastic Oddities Inc.
22	11	$9.00	Plastic	Grainger	PLASTIC ODDITIES
24	12	$8.96	Plastic	Grainger	PLASTIC ODDITIES
26	13	$12.60	Plastic	Grainger	PLASTIC ODDITIES
30	15	$14.86	Plastic	Grainger	PLASTIC ODDITIES
19	9.5	$7.37	Plastic	Home Depot	Oatey
24	12	$7.27	Plastic	Home Depot	Oatey
26	13	$8.97	Plastic	Home Depot	Oatey
22	11	$5.06	Plastic	Hughes Supply Inc	
24	12	$5.70	Plastic	Hughes Supply Inc	
26	13	$7.04	Plastic	Hughes Supply Inc	
30	15	$13.52	Plastic	Lowes	Plastic Oddities Inc.
18	9	$8.02	Plastic	Plastic Oddities Inc.	Plastic Oddities Inc.
20	10	$8.48	Plastic	Plastic Oddities Inc.	Plastic Oddities Inc.
22	11	$8.72	Plastic	Plastic Oddities Inc.	Plastic Oddities Inc.
24	12	$8.66	Plastic	Plastic Oddities Inc.	Plastic Oddities Inc.
24	12	$10.21	Plastic	Plastic Oddities Inc.	Plastic Oddities Inc.
26	13	$12.31	Plastic	Plastic Oddities Inc.	Plastic Oddities Inc.
30	15	$14.18	Plastic	Plastic Oddities Inc.	Plastic Oddities Inc.
24	12	$12.50	Plastic	Whitehead Plumbing Supply	
26	13	$12.50	Plastic	Whitehead Plumbing Supply	
20	10	$11.37		Battelle	
22	11	$11.79		Battelle	
24	12	$16.68		Battelle	
30	15	$27.98		Battelle	

Combining the above data, Table 8-A.3.7 shows the average incremental price for the drain pan for units with 2 in. insulation and 2.5 to 4 in. insulation for each rated storage volume.

Table 8-A.3.7 Drain Pan Incremental Cost for Wider Electric Storage Water Heaters

Tank Size (gal)	**2" Insulation Average Price** *(2009$)*	**2.5-4" Insulation Average Price** *(2009$)*
30	0.75	2.65
40	1.90	5.68
50	1.90	5.68
66	3.77	10.64
75	6.87	17.86
119	18.22	42.49

8-A.3.2 Additional Costs Associated with Space Constraints

A certain fraction of households could incur additional installation costs when installing a water heater with a larger size due to increased insulation. Based on a consultant report, DOE estimated that 30-50% of all replacement installations would require significant modifications in

order to install an electric storage water heater with 3 in insulation. DOE estimated that such constraints would apply to half of the above fraction (i.e., 15-25%) for electric water heater installations with 2 in. insulation.

In situations where significant modifications would be required, there are a number of possibilities that might be applicable to the individual installation. These include:

1. Choosing a water heater with different dimensions (e.g., going with a taller unit)
2. Install a water heater with a smaller rated volume and adding a tempering valve to compensate for lower hot water delivery
3. Modifications to the existing water heater installation location (including removing/replacing door jambs)
4. Relocation of water heater
5. Switching to an electric or gas instantaneous water heater or gas storage water heater

After considering that some houses could choose a different dimension water heater (option 1), DOE assumed that major modifications would be necessary for 40 percent of replacement installations with 3 in. or greater insulation and for 20 percent of replacement installations with 2 in. or greater insulation. For these cases, the most common solutions would be installing a water heater with a smaller rated volume and adding a tempering valve (option 2) or removing/replacing door jambs (option 3). The other installation possibilities have a much lower probability of occurring. DOE estimated that half of the cases where major modifications would be necessary would choose option 2 (tempering valves)[b] and half would select option 3 (door jamb removal/replacement). DOE estimated that option 3 would be selected only in cases where the water heater is installed in an indoor closet or attic (e.g., not in a garage or basement).

option 2, DOE did not adjust the setpoint in its energy use calculations or change the equipment cost for the smaller water heater, as DOE believes these two factors would offset.[c] DOE added the cost of a tempering valve as shown in Table 8-A.3.8.

Table 8-A.3.8 Space Constraint Costs: Use of Tempering Valve

Description	Crew	Labor Hours	Unit	Bare Costs *(2009$)*			Total incl. O&P
				Mat.	Labor	Total	
Trip Charge	1 PLUM*	0.5	Ea.	0.00	21.15	21.15	$31.75
Tempering, water, sweat connections (3/4")	1 PLUM	0.4	Ea.	79.50	16.92	96.42	$112.85
Total		0.9		79.50	38.07	117.57	**$144.60**

* 1 PLUM means a crew of 1 plumber.

[b] Tempering valve was applied to water heaters with 2.5 in. or greater insulation to match what was used in the 2001 water heater rulemaking.

[c] The tempering valve strategy involves increasing the setpoint temperature so that the total energy content of the water that can be delivered from the smaller water heater is equivalent to the content delivered by the original water heater at a lower temperature. Increasing the setpoint temperature will increase the water heater standby losses, which is generally offset by lower equipment cost for the smaller water heater.

DOE estimated the cost for option 3 (door jamb removal/replacement) as shown in Table 8-A.3.9.

Table 8-A.3.9 Space Constraint Costs: Door Modifications – Door Jambs

Description	Crew	Labor Hours	Unit	Bare Costs *(2009$)*			Total incl. O&P
				Mat.	Labor	Total	
Trip Charge	1 CARP*	0.5	L.F.	0.00	17.33	17.33	26.88
Remove and replace interior door casing, jamb and stop	1 CARP	1.2	L.F.	0.00	41.60	41.60	$64.52
Remove and replace interior slab door, on existing hinges (includes new door)	1 CARP	2.0	L.F.	0.00	69.33	69.33	$107.54
Total		3.7		0.00	128.27	128.27	**$198.94**

* 1 CARP means a crew of 1 carpenter.

8-A.3.3 Incremental Installation Costs for Heat Pump Water Heaters

Current heat pump water heaters (such as the GE hybrid water heater and Rheem heat pump water heater) are designed to be drop-in replacement models to current electric storage water heater models. Given their larger size compared to current electric storage water heater models and additional installation requirements for the heat pump component, DOE considered several additional costs for heat pump water heaters on top of the other basic installation costs described in section 8-A.3.1. These additional installation costs include:

1) Additional labor hours required
2) Condensate pump
3) Costs for addressing space constraints
4) Space constraints venting adder
5) Drain pan

8-A.3.3.1 Additional Labor Hours

In 2004, the CEC conducted 20 installations of heat pump water heaters in California.[7] In this report it was estimated that heat pump water heaters would take on average 1 to 1.5 hours longer to install than standard electric storage water heaters. Similar results were found in installations done in the eastern U.S. The additional labor accounts for $64 (labor to add a condensate removal, larger size, etc.) DOE applied a distribution of additional labor hours from zero to two hours, with an average of one additional labor hour, to all heat pump water heater installations (Table 8-A.3.10).

Table 8-A.3.10 Installation Adder for Heat Pump Water Heaters

Description	Crew	Labor Hours	Unit	Bare Costs *(2009$)*			Total incl. O&P
				Mat.	Labor	Total	
Installation Adder	2 PLUM*	1	Ea.	0.00	42.30	42.30	**$63.50**

* 1 PLUM means a crew of 1 plumber.

8-A.3.3.2 Condensate Pump Cost

DOE assumed that most electric storage water heaters are installed near a drain, so it estimated that only one quarter of all heat pump water heater installations would require addition of a condensate pump and longer water line to the drain. For replacement installations requiring a condensate pump, DOE included a distribution of costs from $84.53 to $222.63.

8-A.3.3.3 Costs for Addressing Heat Pump Water Heater Space Constraints

DOE assumed that the space constraints encountered when installing heat pump water heaters would be similar to those encountered when installing electric storage water heaters with 3 in. insulation. In addition, heat pump water heaters are required to be in well-ventilated spaces. Based on the water heater location, for the NOPR DOE estimated that (1) 40 percent of replacement installations would encounter space constraints, (2) half of the cases (where ventilation is not a significant issue) would choose a smaller water heater with a higher setpoint and a tempering valve, and (3) the other half (where ventilation is an issue) would choose door jambs removal/replacement and adding a louvered door.

Regarding the use of a smaller water heater with a higher setpoint and a tempering valve, for the final rule DOE reduced the fraction of installations that would use a tempering valve to include only those cases where the water heater setpoint would not need to exceed 140°F, as recommended in GE product literature. DOE assumed that those households for which the tempering valve strategy is not viable would incur costs to modify the space to accommodate the heat pump water heater.

Regarding the approach of adding a louvered door, DOE believes that there are legitimate concerns about the extent to which installing a louvered door will provide adequate air flow for closet installations of heat pump water heaters. For the final rule analysis, DOE decreased the number of cases using the louvered door approach. Instead, DOE assumed that some households would install a venting system, which would provide adequate air flow and also alleviate excessive cooling of the indoor space near the water heater (see discussion below).DOE assumed that households not installing a venting system would choose door jambs removal/replacement and adding a louvered door. DOE estimated the cost for removing the door jambs and installing a louvered door as shown in Table 8-A.3.11.

Table 8-A.3.11 Space Constraint Costs: Closet Modifications – Louvered Door

Description	Crew	Labor Hours	Unit	2008 Bare Costs *(2009$)*			Total incl. O&P
				Mat.	Labor	Total	
Trip Charge	1 CARP*	0.5	L.F.	0.00	$17.33	$17.33	$26.88
Remove and replace interior door casing, jamb and stop	1 CARP	1.2	L.F.	0.00	$41.60	$41.60	$64.52
Remove and replace interior slab door, on existing hinges (includes new louvered door)	1 C ARP	2.0	L.F.	115.00	$69.33	$184.33	$234.04
Total		3.7		115.00	$128.27	$243.27	$325.44

* 1 CARP means a crew of 1 carpenter.

8-A.3.3.4 Venting System Adder

Heat pump water heaters can increase heating loads when installed in a conditioned space during the heating season. DOE estimated that about 35 percent of households in the subsample for electric water heaters would experience significant indoor cooling due to operation of the heat pump water heater in the heating months ("significant" means that the heat pump water heater adds 3 MMBtu to the indoor space over the heating season). Of these, DOE estimated that 100 percent of households with a significant cooling effect would incur this cost, which is described in Table 8-A.3.12.[d] (A heat pump water heater designed in Europe uses this strategy.[8]) For new construction, the unit is assumed to be installed in a space where indoor cooling is not an issue.

Using calculations specific to each household in the subsample for electric water heaters, The cost varies depending on the length of the PVC venting, which is determined by assuming that the water heater is installed in the middle of the house and then calculating the average distance from the middle to the nearest wall. This length is then doubled so that the system takes in the supply air from the outside, as well as venting out the cold air. On average DOE calculated that the vent length required would be a total of 50 feet.

Table 8-A.3.12 Heat Pump Water Heater Venting Installation Cost Adder (Average)

Description	Crew	Labor Hours	Unit	2008 Bare Costs *(2009$)*			Total incl. O&P
				Mat.	Labor	Total	
PVC, couplings 10' O.C., hangars 3 per 10', schedule 40 (2" Diameter)	Q1*	0.08	L.F.	1.25	3.08	4.33	$251.82
PVC, schedule 40, socket joints, 90" elbow, 1/2" (2" diameter)	Q1	0.44	EA	2.18	16.75	18.93	$27.54
Exhaust Fan	Q1	0.50	EA	50.00	19.04	69.04	$83.57
Knockouts to 8' high, metal boxes & enclosures (With hole saw, 2" pipe size)	1 ELEC**	0.30	EA	0.00	12.07	12.07	$35.93
Total		1.32		53.43	50.94	104.37	**$398.86**

* 1 Q1 means a crew comprised of 2 plumbers and 1 plumber apprentice.
** 1 ELEC means a crew of 1 electrician.

DOE estimated that that in some cases it would be necessary to install the venting system outside the wall structure, where the exposed vents would likely be covered. Therefore, it assumed that some of the venting system installations would incur an additional cost for covering the exposed vents (see table 8-A.3.13).

[d] For the remainder of homes experiencing a cooling effect, the extra cost for space heating is accounted in the energy use calculations, as described in chapter 7.

Table 8-A.3.13 Costs of Concealing HPWH Venting

Description	Crew	Labor Hours	Unit	Bare Costs *(2009$)*			Total incl. O&P
				Mat.	Labor	Total	
Trip Charge	1 CARP*	0.5	Ea.	0.00	17.33	17.33	$26.88
Wallboard repair 8"-12" (cut square, patch san and repair finish)	1 CARP	0.5	C.L.F.	3.04	17.33	20.37	$482.78
Total		1.0		3.04	34.67	37.71	**$509.66**

* 1 CARP means a crew of 1 carpenter.

8-A.3.3.5 Drain Pan Incremental Cost

For installation of heat pump water heaters, DOE also applied an additional drain pan cost to account for the larger insulation for this product. The costs are shown in Table 8-A.3.7.

8-A.4 OIL-FIRED STORAGE WATER HEATERS

An oil-fired water heater installation requires hot and cold water connections, oil supply, electrical power connection, a vent connection and an oil-burner that consists of oil pump, blower, ignition device, and controls. DOE developed installation cost data for baseline oil-fired waters heater using information from the 2001 water heater rulemaking.[3] All design options are assumed to have the same installation costs.

8-A.5 INSTANTANEOUS GAS WATER HEATERS

DOE developed installation cost data for gas-fired instantaneous water heaters using RS Means books,[1, 2, 3, 4, 5] DOE technical support documents,[1, 2, 3, 4, 5] and a consultant report prepared for this analysis.[1, 2, 3, 4, 5]

It can be difficult to use instantaneous water heaters as a replacement technology in many existing homes as the cost of physically accommodating their installation can add considerable expense.[9] DOE's derivation of installation cost does not consider extreme installation configurations. The analysis assumes that all replacements are a conversion from gas-fired storage water heaters. This reflects the small number of instantaneous water heaters installed during the 1980s and 1990s and the long lifetime of these products.

The baseline represents an instantaneous water heater with a pilot light and natural draft venting. For new construction applications, the installation cost includes adding a gas line branch (since in most cases it is not possible to connect the water heater to the existing house gas line, which is too small), installing a vent system, adding water piping, as well as the cost of putting in place and setting up the new water heater. For replacement cases, the installation cost includes the labor for disconnecting and removing the old water heater, putting in place and setting up the new instantaneous water heater, adding a vent system, and removal/disposal and permit fees. The

analysis for both new construction and replacements assumes Category I vertical venting using non-stainless steel vents.

For installations of gas-fired instantaneous water heaters with electronic ignition, DOE added an additional cost to account for labor and wiring for installing an electrical outlet for houses that do not have electricity close to the water heater. DOE used the same approach it applied to gas-fired storage water heaters (see section 8-A.2.4).

The incremental installation cost for the forced draft/power vent design includes the cost of installing an electrical outlet for houses that do not have electricity close to the water heater and the required venting. The cost reflects Category III venting using stainless steel vents. For replacement installations, DOE estimated that half of the installations will use vertical vents and half will use horizontal vents. The venting systems are configured to exit a side wall of a dwelling and are composed of plastic vent pipes. For replacement installations, DOE accounted for the installation of a new vent system, and for the commonly-vented water heaters, for disconnecting from the existing common system.

The installation cost for the condensing design utilizes plastic vents (in addition to the forced draft and electronic ignition) and includes the cost of the condensate disposal.

8-A.6 DIRECT HEATING EQUIPMENT

DOE derived baseline installation costs for direct heating equipment (DHE) using the approach from the 1993 TSD.[10] For gas wall gravity DHE, gas floor DHE and gas room DHE, DOE added an additional installation cost for the design options that require electricity. This was done for the replacement market only, since in new construction the wiring is considered part of the general electrical work. DOE determined the cost of an additional electrical outlet to be $183 for gas wall gravity DHE, $159 for gas room DHE, and $169 for gas hearth DHE. DOE estimated that grounding for an electrical outlet is needed for houses built before 1960 at a cost of $37 for gas wall gravity DHE, $32 for gas room DHE, and $34 for gas hearth DHE. See section 8-A.2.4 for cost calculation details.

DOE added an additional installation cost for the design options requiring stainless steel venting (e.g. 83% gas room DHE efficiency level). This yields an average cost of $80. For gas hearth DHE at condensing efficiency level, DOE did not add any cost adder. DOE considered that the additional replacement installation cost is offset by the decreased installation costs for new owners and new construction.

DOE assumed that for the max tech level for gas fan wall furnace DHE (80% AFUE), adding to the heat exchanger to increase efficiency will make upright models bigger such that they may not be able to fit in the same space as the unit they are replacing. As a result, DOE added installation cost associated with the carpentry cost for cutting and repairing the wall to increase the dimensions of the wall opening for a fraction of installations, as well as making some venting modifications. The fraction takes into account that some installations are "console units" and do not have this issue, and that some upright installations are not installed inside the

wall and therefore do not have this issue. The average cost is $142 for the carpentry work and $50 for venting modifications.

8-A.7 POOL HEATERS

DOE derived installation cost data for the baseline pool heater using RS Means[5] and information in a consultant report.[11] The baseline unit represents a pool heater with a pilot light or electronic ignition. For new construction applications, the installation cost includes adding a gas line from the gas meter to the pool heater (in most cases it is not possible to connect the pool heater to the existing house gas line as it is too small). It also includes adding PVC lines from the pool pump to the inlet and outlet water headers of the pool heater (thermal isolation - non - PVC pipe is usually part of this line to prevent pool pump overheating). The installation cost also includes set-up, connection and start-up fees. For the replacement applications, the installation cost includes disconnecting and removing the old pool heater, putting in place the new unit and reconnecting the gas and PVC lines. DOE assumed that 10% of the time the installation will require more labor due to a more complex installation. Table 8-A.7.1 and Table 8-A.7.2 show the low installation costs for new construction and replacement installations, which are applicable to 90% of installations.

Table 8-A.7.1 New Construction Costs (Low Cost, 90% of Installations)

Description	Crew	Labor Hours	Unit	Bare Costs *(2009$)*			Total incl. O&P
				Mat.	Labor	Total	
Setting, connecting, start-up	Q6*	8.00	Ea.	0.00	373.22	373.22	$560.20
Water Piping (Schedule 40, threaded, with couplings, and clevis hanger, 1" diameter)	Q6	0.12	L.F.	1.09	5.68	6.77	$486.13
Gas Piping 1" diameter (Schedule 40, threaded, with couplings, and clevis type hangars, 10' O.C., black)	Q6	0.13	L.F.	3.22	5.99	9.21	$1,253.14**
Connection to P-Trap PVC lines	Q6	1.00	Ea.	35.00	46.65	81.65	$108.53
Total		9.25		39.31	431.54	470.85	**$2,407.99**

* 1 Q6 means a crew comprised of 2 steamfitters and 1 steamfitter Apprentice.
** For LPG, the total cost (including O&P) for this activity is $62.66. The smaller cost results from the proximity of the fuel source when compared to piped natural gas.

Table 8-A.7.2 Replacement Costs (Low Cost, 90% of Installations)

Description	Crew	Labor Hours	Unit	Bare Costs *(2009$)*			Total incl. O&P
				Mat.	Labor	Total	
Trip Charge	Q1	1	Ea.	0.00	44.43	44.43	$66.69
Setting, connecting, start-up	Q1	2	Ea.	0.00	88.87	88.87	$133.39
Remove old pool heater	Q1	1	Ea.	0.00	44.43	44.43	$66.69
Connection to P-Trap PVC lines or redo condensate	Q1	1	Ea.	35.00	44.43	79.43	$105.19
Total		5		35.00	222.16	257.16	**$371.97**

* 1 Q1 means a crew comprised of 2 plumbers and 1 plumber apprentice.

For units with electronic ignition, DOE included an additional installation cost to account for adding an electrical line (115V) and a separate junction box. These are needed since the pool heater requires lower amperage than the pool pump. Table 8-A.7.3 and Table 8-A.7.4 show the corresponding costs respectively for new constructions and replacements.

Table 8-A.7.3 New Construction Costs for Electricity Connections

Description	Crew	Labor Hours	Unit	Bare Costs *(2009$)*			Total incl. O&P
				Mat.	Labor	Total	
Motor Connections (Flexible conduit and fitting, 115 volt, 1 phase, up to 1 HP motor)	1 ELEC*	1.00	Ea.	9.00	47.60	56.60	**$80.72**

* 1 ELEC means a crew comprised of 1 electrician.

Table 8-A.7.4 Replacement Costs for Electricity Connections

Description	Crew	Labor Hours	Unit	Bare Costs *(2009$)*			Total incl. O&P
				Mat.	Labor	Total	
Trip Charge	1 ELEC*	0.50	Ea.	0.00	23.80	23.80	$35.41
Lighiting outlets (Box (4") and wire (for fixture), Type NM cable)	1 ELEC	0.32	Ea.	0.00	15.23	15.23	$22.66
Motor Connections (Flexible conduit and fitting, 115 volt, 1 phase, up to 1 HP motor)	1 ELEC	1.00	Ea.	9.00	47.60	56.60	$80.72
Total		1.82					**$138.80**

* 1 ELEC means a crew comprised of 1 electrician.

For the condensing design, DOE added an incremental installation cost of $100 that includes the cost of the condensate drain piping that goes from the pool heater to a P-trap device[e] located at the sewer line entrance.[11]

8-A.8 RS MEANS 2009 REGIONAL LABOR COSTS

DOE used regional labor costs to more accurately estimate installation costs by region. RS Means provides average national installation costs for different trade groups as shown in Table 8-A.8.1. Bare costs are given in RS Means, while labor costs including overhead and profit (O&P) are the bare costs multiplied by the RS Means markups by trade shown in Table 8-A.8.1.

[e] A "P-trap" is required by many city codes. It helps to isolate the condensate from back-flowing into the pool water and prevents the sewer gas from back-flowing.

Table 8-A.8.1 RS Means 2009 National Average Labor Costs by Crew (Standard Union)

Crew Type	Crew Description	Laborers per Crew	Cost per Labor-Hour	
			Bare Costs	Incl. O&P*
2 Plum (Crew L-1)	2 Plumbers	2	$46.70	$70.24
1 Elec	1 Electrician	1	$47.00	$69.94
Q1	1 Plumber, 1 Plumber Apprentice	2	$42.03	$63.21
1 Carp	1 Carpenter	1	$38.10	$59.28

* Q&P includes markups in Table 8-A.8.2

Table 8-A.8.2 RS Means Labor Costs Markups by Trade (Standard Union)

Trade	Workers Comp.	Aver Fixed Overhead	Overhead	Profit	Total
Plumber	8.1%	16.3%	16.0%	10.0%	50.4%
Electrician	6.5%	16.3%	16.0%	10.0%	48.8%
Carpenter	18.3%	16.3%	11.0%	10.0%	55.6%

RS Means also provides labor cost factors for 295 cities and towns in the U.S. To derive average labor cost values by State, DOE weighted the price factors by city or town population size using 200 census data. Since RECS 2005 household location is identified by the nine census divisions and 4 large States, DOE then population weighted the State data using 2008 Census data into the appropriate nine census divisions and 4 large States. Table 8-A.8.3 shows the final regional price factors used in the analysis.

Table 8-A.8.3 Final Labor Cost Factors by Census Division and Four Large States

Census Division and 4 large states	Census Division Name	States	Labor Cost Factor
1	New England	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont	1.18
2	Middle Atlantic*	New Jersey, Pennsylvania	1.27
3	East North Central	Indiana, Illinois, Michigan, Ohio, Wisconsin	1.12
4	West North Central	Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota	0.97
5	South Atlantic**	Delaware, District of Columbia, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia	0.73
6	East South Central	Alabama, Kentucky, Mississippi, Tennessee	0.75
7	West South Central***	Arkansas, Louisiana, Oklahoma	0.66
8	Mountain	Arizona, Colorado, Idaho, New Mexico, Montana, Utah, Nevada, Wyoming	0.82
9	Pacific****	Alaska, Hawaii, Oregon, Washington	1.06
10		New York	1.66
11		California	1.25
12		Texas	0.66
13		Florida	0.72

* Includes New York, which is separated out as a large state.
** Includes Florida, which is separated out as a large state.
*** Includes Texas, which is separated out as a large state.
**** Includes California, which is separated out as a large state.

The distribution of each RECS 2005 product class sample is different, so the average labor cost weighted by RECS 2005 sample weights is different from the RS Means national average (i.e., labor cost factor of 1.00). Table 8-A.8.4 shows the fraction of households in each division and four large states each product class sample and the resulting average labor cost.

Table 8-A.8.4 Final Labor Cost Factors by Census Division and Four Large States

Census Division and 4 large states	Labor Cost Factor	Fraction of Households in RECS 2005 Sample								
		GSWH	ESWH	OSWH	GIWH	PH	GWF/ GWG	GF	GR	GH
1	1.19	3.6%	2.9%	44%	3.7%	4%	1.2%	0.6%	2.7%	1.0%
2	1.28	8.3%	4.7%	24%	8.2%	6%	2.6%	2.8%	1.5%	5.3%
3	1.12	20.2%	12.0%	0%	20.2%	13%	8.1%	8.6%	9.1%	17.2%
4	0.99	9.1%	5.4%	0%	9.1%	2%	5.9%	5.2%	5.5%	9.6%
5	0.73	7.9%	22.4%	2%	7.9%	10%	6.5%	7.0%	16.6%	12.9%
6	0.75	3.7%	11.5%	0%	3.7%	3%	1.7%	1.9%	17.0%	9.3%
7	0.66	4.1%	4.3%	0%	4.0%	0%	5.7%	6.1%	13.5%	0.0%
8	0.82	9.4%	4.6%	0%	9.5%	7%	15.0%	12.8%	3.3%	14.5%
9	1.08	2.7%	6.6%	0%	2.6%	3%	2.9%	3.1%	2.3%	9.8%
10	1.66	4.8%	1.3%	31%	4.8%	5%	0.0%	0.0%	2.5%	1.2%
11	1.23	17.4%	2.0%	0%	17.3%	20%	50.4%	51.9%	16.4%	12.3%
12	0.66	7.6%	7.7%	0%	7.6%	12%	0.0%	0.0%	9.7%	4.5%
13	0.73	1.3%	14.8%	0%	1.3%	13%	0.0%	0.0%	0.0%	2.3%
Average Labor Cost Factor		1.04	0.87	1.34	1.04	1.01	1.08	1.08	0.91	0.97

REFERENCES

1. U.S. Department of Energy - Energy Efficiency & Renewable Energy, *Technical Support Document: Energy Efficiency Standards for Consumer Products: Residential Furnaces and Boilers*, 2007. Washington, DC.

2. RS Means Company Inc., *Facilities Maintenance & Repair Cost Data 2005*. 2004. Kingston, MA.

3. U.S. Department of Energy - Energy Efficiency & Renewable Energy, *Technical Support Document: Energy Efficiency Standards for Consumer Products: Residential Water Heaters*, 2001. Washington, DC.

4. Smith, D. C., *Consultant Report - Water Heater Installation Costs*, 2008. Florence, SC.

5. RS Means Company Inc., *2008 Mechanical Cost Data - 31st Annual Edition*. 2007. Kingston, MA.

6. Dini, D. A., *Some History of Residential Wiring Practices in the U.S.*, 2006. Underwriters Laboratories Inc.

7. California Energy Commission, *Consultant Report: Design Refinement and Demonstration of a Market-Optimized Heat-Pump Water Heater*, April, 2004. California Energy Commission - Public Interest Energy Research Program. <http://www.energy.ca.gov/reports/500-04-018/2004-05-21_500-04-018.PDF>

8. Inventum BV, *Ecolution Optima Brochure*, Inventum BV. (Last accessed April 24, 2008.) <http://www.inventum.nl/folders/en/Ecolution.pdf>

9. Hewitt, D., Jeff Pratt and Gary Smith, *Tankless Gas Water Heaters: Oregon Market Status: Final Report*, December 6, 2005. Energy Trust of Oregon.

10. U.S. Department of Energy-Office of Codes and Standards, *Technical Support Document: Energy Efficiency Standards for Consumer Products: Room Air Conditioners, Water Heaters, Direct Heating Equipment, Mobile Home Furnaces, Kitchen Ranges and Ovens, Pool Heaters, Fluorescent Lamp Ballasts & Television Sets*, 1993. Washington, DC Vol. 1 of 3. Report No. DOE/EE-0009.

11. Hamos, R., *Consultant Report - Pool Heater Installation Costs*, 2008.